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UV EMISSION AS DIAGNOSTICS FOR WIND DYNAMICS IN CATACLYSMIC VARIABLES

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I. PROJECT SUMMARY AND RESULTS

We have used the *IUE* database to analyze the UV line shapes of cataclysmic variables (hereafter CVs). The standard reduction package at the *IUE* Regional Data Analysis Facility (University of Colorado at Boulder) was used for this purpose. In total, eight novalike variables (25 observations) and five dwarf-novae (28 observations) have been considered. We have concentrated on low-resolution spectra obtained with Short Wavelength Prime camera between $1,150 - 1,950$Å. Only large aperture spectra have been used to avoid possible errors in centering. To allow for instrumental broadening the line profiles were smoothed with a gaussian of FWHM$\sim$ 4.5Å.

The observed lines have been compared to synthetic line profiles computed using a kinematic and radiation-transfer model of 3-D rotating bi-conical wind from an accretion disk around white dwarf. This was done by developing and testing numerical code which can handle both the wind kinematics and multidimentional line-transfer. The wind streamlines have been taken as helices that start on the disk surface and continue on the conical surface which has a constant opening angle. The wind is assumed to conserve its specific angular momentum around the rotation axis.

The line radiation transport model in the wind is based on the Sobolev method. The radiation field is created by the white dwarf, the boundary layer and the accretion disk itself. We have calculated the line spectrum by evaluating the scattered luminosity from the wind and the net unscattered luminosity separately. The accretion disk was assumed to be optically thick as long as its blackbody temperature exceeds 8,000 °K. The boundary layer is optically thick. The ionization balance in the wind was calculated taking a constant temperature in the wind and a local ionization equilibrium. All ions of H, He, C, N and O have been considered with solar abundances.

In order to understand the relative importance of different physical conditions in the wind, boundary layer and the accretion disk, we have performed a parameter search for synthetic line profiles. We have demonstrated that taking into account the observed dispersion in the primary masses, inclination angles and the accretion rates in CV systems, good fits to the observations can be obtained by using our model for a non-radial rotating winds. We find that, based on our kinematic model, disk winds can reproduce the observed line profiles from CVs, which include P Cygni profiles at low inclination and pure emission lines at large inclination without invoking additional assumptions.

In particular we have concentrated on three nova-like CVs at different inclinations that experience no eclipse, partial eclipse and full eclipse. These are RW Sex, RW Tri and V Sge. A similar study of dwarf novae in outburst is in progress.

We find that the minimum of the line absorption profile residual flux occurs close to the line center, typically blueshifted by few hundred km s^{-1}. The best line fits (to the archive spectra of the above nova-like CVs) were obtained by using a power law profile with acceleration slightly faster than linear and with the wind acceleration scale height much larger than the radius of the white dwarf. The self-consistent photionization model for the wind has allowed us to identify and to accurately map the resonant scattering regions above the disk. We have been able to show that for a broad range of disk wind parameters the scattering region extends well above the disk and has a strongly bi-conical character.

We also find that disk winds are preferable to spherical winds which originate on the white dwarf for few reasons: (1) disk winds require a much lower ratio of outflow-to-accretion rates for systems which show P Cygni profiles, such as RW Sex, making them more plausible on the energy grounds, especially if the winds are driven by radiation pressure. For high inclination systems, such as RW Tri, the absence of an observed absorption profile limits the mass loss rate for spherical winds resulting in too narrow line profiles. (2) In the disk winds, the matter is channeled into extended bi-conical emission regions above the disk, which naturally explains why the UV line do not experience eclipse when the continuum does and why high inclination systems do not show absorption features. (3) The rotation in the wind introduces a radial shear in the velocity field which decreases the resonance line optical depth and reduces the line center intensity. This effect should be observable with the high-resolution instruments, such as HST. Rotation is also responsible for some amount of redshifted absorption which should be potentially observable in the low-to-intermediate inclination systems with weak line emission.

We find that a unique fit to the observed line profiles is not possible on the basis of kinematic model alone. However, a dynamical model for a 2-D outflow from a disk should remove these limitations.

We have applied the model of a rotating wind from accretion disk to active galactic nuclei (AGNs) in order to explain the same lines observed from these systems. We believe that similarities exist between these extragalactic systems and CVs. Because the broad emission lines in AGNs are believed to form in magnetically or radiatively-driven winds from accretion disks, this study may provide a valuable information on the dynamics and geometry of winds in CVs. We have been able to reproduce typical line profiles with cusp shapes, blue asymmetry and blue-shifted peaks. We have found also that the volume emissivity in the wind must scale with the distance from the rotation axis roughly as $r^{-3.3}$. We have shown that wings of the broad lines may form through electron scattering. The actual line fitting was done for two objects: Q1101-264 and PG1247+265.

II. PUBLICATION LIST

1. Blandford, R.D., Emmering, R.T. & Shlosman, I. (1991) in Proc. Taipei Astrophysics Workshop on *Relationship between AGNs and Starburst Galaxies,* A.Filippenko (ed.), ASP Conference Series.
2. Emmering, R.T., Blandford, R.D. & Shlosman, I. *Astrophys. J.* **385**, 460 (1992).
3. Vitello, P.A.J. & Shlosman, I. (1992) in Proc. X International Colloq. on *UV and X-Ray Spectroscopy of Astrophysical and Laboratory Plasmas*, S.M.Kahn (ed.), Cambridge Univ. Press, in press.
4. Shlosman, I. & Vitello, P.A.J. *Astrophys. J.* , in preparation.
5. Vitello, P.A.J. & Shlosman, I. *Astrophys. J.* , submitted.